SPATIAL AND TEMPORAL DISTRIBUTION OF BUTTERFLY IN HIGHLAND AND LOWLAND FORESTS OF JOHOR

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DEDICATION

My humble effort and success, I dedicate to my dearest Mother, Brothers and Sisters, who always give me their unconditional love, patience, support and constant prayers day and night that made me able to finish my research and this thesis.

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ABSTRACT

Johor is a fast developing state and if unchecked could lead to loss of biodiversity. Among insects, butterfly is an important bioindicator of environmental changes. For effective management purposes, a baseline data of butterfly is needed. Samplings were carried out in various forest types: Taman Negara Johor Endau Rompin (TNJER), a lowland forest (30 to 100 m above sea level (a.s.l.)) and Taman Negara Johor Gunung Ledang (TNJGL), a highland forest (400, 800 and 1200 m a.s.l.). The objectives of this research were (i) to document butterfly diversity in TNJER and TNJGL, (ii) to analyse species diversity patterns based on faunistic aspect, (iii) to determine temporal distributions based on seasonal variations and (iv) to relate the effects of environmental parameter on butterfly's diversity. Samplings were done manually (along 2 km transect) and trapping using fruit bait (rotten banana and pineapple) over a period of 15 months from April 2014 until July 2015. A total of 1125 individuals comprising 191 butterfly species from five families were collected and recorded. Nymphalidae was the most well- represented family. The values of Shannon Diversity Index (H') and Species Evenness Index (E') were higher in TNJER (H'=4.123; E'=0.471) than TNJGL (H'=3.405; E'=0.235). Based on elevations, 400 m a.s.l. had the highest species index (H'=4.169) and more even distribution (E'=0.660) compared to the two higher altitudes. Temporally, the diversity index was the highest in May (H'=3.357) and lowest in June (1.639) at TNJER and indicated the highest species similarity occurring between April and May. In TNJGL, the diversity was the highest in May (H'=3.626) and lowest during June (2.012) and resulted greatest similarity between June and August. However, this study found no significant relationships ($p > 0.05$) between environmental parameters (humidity and temperature) and diversity (species richness and abundance) at different elevations. The spatial and temporal approaches used in this study would increase in understanding on the impact of altitudinal and climatic changes on butterfly's diversity and provide baseline data for Johor that would be useful for biodiversity monitoring and conservation of the protected areas.

ABSTRAK

Johor merupakan negeri yang sedang pesat membangun dan pembangunan yang berterusan akan menyebabkan kehilangan kepelbagaian biologi. Di kalangan serangga, kupu-kupu merupakan penunjuk biologi bagi perubahan persekitaran. Bagi tujuan pengurusan dan konservasi yang berkesan, data awalan amatlah penting. Jadi, persampelan telah dijalankan di hutan yang berbeza: hutan tanah rendah, Taman Negara Johor Endau Rompin (TNJER) (30 ke 100 m atas aras laut) dan hutan tanah tinggi, Taman Negara Johor Gunung Ledang (TNJGL) (400, 800 dan 1200 m atas aras laut). Objektif kajian adalah (i) mendokumentasikan kepelbagaian kupu-kupu di TNJER dan TNJGL, (ii) meninjau aspek faunistik kupu-kupu, (iii) mengukur taburan kupu-kupu berdasarkan musim dan (iv) mengaitkan kesan pengaruh persekitaran terhadap kepelbagaian kupu-kupu. Persampelan dijalankan secara manual sepanjang transek 2 km dan pemasangan perangkap berumpan (pisang dan nenas busuk) selama 15 bulan dari April 2014 hingga Julai 2015. Secara keseluruhan, sebanyak 1125 individu kupu-kupu mewakili 191 spesies dari lima famili telah direkodkan. Nymphalidae merupakan famili paling menyerlah dan melimpah. Analisis Indeks Kepelbagaian Spesies Shannon (H') dan Kesamarataan Spesies (E') mencatatkan nilai tertinggi di TNJER (H'=4.123; E'=0.471) berbanding TNJGL (H'=3.405; E'=0.235). Berdasarkan ketinggian, 400 m atas aras laut mencatatkan nilai indeks spesies tertinggi (H'=4.169) dan taburan spesies lebih sekata (E'=0.660) berbanding kawasan lebih tinggi. Manakala, indeks spesies paling tinggi ialah pada Mei (H'=3.357) dan terendah pada Jun (1.639) di TNJER dan persamaan spesies tertinggi berlaku di antara April dan Mei. Di TNJGL, kepelbagaian spesies paling tinggi pada Mei (H'=3.626) dan paling rendah pada Jun (2.012) dan menunjukkan persamaan spesies tertinggi di antara Jun dan Ogos. Namun, kajian ini menunjukkan tiada hubungan yang signifikan ($p>0.05$) antara pengaruh persekitaran (kelembapan dan suhu) dan kepelbagaian (kekayaan dan kelimpahan spesies) di ketinggian yang berbeza. Pendekatan menurut ruang dan masa yang telah digunakan dalam kajian ini telah meningkatkan kefahaman tentang kesan ketinggian dan perubahan iklim terhadap kepelbagaian kupu-kupu. Di samping itu, kajian ini turut menghasilkan data awalan bagi negeri Johor untuk digunakan sebagai alat mengukur penilaian biodiversiti dan konservasi kawasan yang dilindungi.

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LIST OF SYMBOLS AND ABBREVIATIONS

°C	-	Degree celsius
a.s.l.	-	Above sea level
CBioD	-	Conservation of Biological Diversity
CM	-	Centrimetre
CTI	-	Community Temperature Index
DWNP	-	Department of Wildlife and National Parks
E'	-	Species Evenness Index
FRIM	-	Forest Research Institute Malaysia
GEF	-	Global Environment Facility
H'	-	Shannon Diversity Index
i.e.	-	*id est* (that is)
IPCC	-	Intergovernmental Panel on Climate Change
ITTO	-	International Tropical Timber Organization
JNPC	-	Johor National Park Corporation
JPM	-	Jabatan Perdana Menteri
K. Jasin	-	Kuala Jasin
km	-	Kilometre
LUX	-	Unit of light intensity
m	-	Metre
m/s	-	Metre per second
mm	-	Millimetre
MONRE	-	Ministry of Natural Resources and Environment
MS Excel	-	Microsoft excel
n	-	Number of individual
NERC	-	Nature Eduction and Research Centre
PAST	-	Paleontological Statistics
RBA	-	Rapid Biodiversity Assessment
RH	-	Relative humidity
TNJER	-	Taman Negara Johor Endau Rompin
TNJGL	-	Taman Negara Johor Gunung Ledang
UK	-	United Kingdom

UNDP	-	United Nations Development Programme
UNEP-WCMC	-	United Nations Environment Programme World Conservation Monitoring Centre
UTHM	-	Universiti Tun Hussein Onn Malaysia

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LIST OF PUBLICATIONS

Proceedings/Conferences/ Seminars

Oral Presentations

i. **Ismail, N.,** Maryati, M., Phon, C.K. & Tokiman, L. (2016). Pemuliharaan dan kepelbagaian biologi kupu-kupu (Lepidoptera: Rhopalocera) di Johor, Malaysia in *Kolokium Pengurusan dan Pembinaan (Siri 1) 2016 on 20 January 2016 at Hotel Katerina, Batu Pahat, Johor.*

ii. **Ismail, N.,** Maryati, M., Phon, C.K. & Tokiman, L. (2016). Butterfly (Lepidoptera: Rhopalocera) diversity along altitudinal gradients of Gunung Ledang National Park, Johor, Malaysia in *2nd Entomology Postgraduate Symposium 2016 on 29-30 Mac 2016 at Hotel Bangi-Putrajaya.*

iii. **Ismail, N.** & Maryati, M. (2016). Preliminary list of butterflies (Lepidoptera: Suborder Rhopalocera) in gelam swamp and dipterocarp forest of Setiu, Malaysia in *Seminar Ekspedisi Tanah Bencah Setiu 2016 on 13 Oktober 2016 at Universiti Malaysia Terengganu.***(In press.)**

iv. **Ismail, N.,** Maryati, M. & Phon, C.K. (2016). Butterflies (Lepidoptera: Rhopalocera) diversity at Taman Negara Johor Endau Rompin and prioritizing the potential groups for nature tourism product in *Seminar Biodiversiti 2016 on 21-25th November 2016 at Awana Hotel, Genting Highlands, Pahang.*

v. **Ismail, N.** & Maryati, M. (2017). Preliminary checklist of butterflies (Lepidoptera: Rhopalocera) at Bukit Reban Kambing, Bukit Belading and Bukit Tukau, Johor in *Seminar Warisan Semulajadi Johor 2017 on 13 – 14 March 2017 at M Suite Hotel, Johor Bahru, Johor.* **(In press.)**

vi. Awg, A.A.R., **Ismail, N.** & Maryati, M. (2017). Preliminary checklist of butterflies (Lepidoptera: Rhopalocera) at Ulu Sedili Besar Forest Reserve, Johor, Malaysia in *Seminar Warisan Semulajadi Johor 2017 on 13 – 14 March 2017 at M Suite Hotel, Johor Bahru, Johor.* **(In press.)**

vii. **Ismail, N.** & Maryati, M. (2017). The uniqueness of Taman Negara Johor Endau Rompin: Butterflies in *Kolokium UMS-UTHM 2017 on 3 April 2017 at Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah.*

Poster presentations

i. **Ismail, N.,** Maryati, M., Phon, C. K. & Tokiman, L. (2015). Butterflies (Lepidoptera: Rhopalocera) of Endau Rompin National Park, Johor, Malaysia inclusive of twenty-seven new records in *International Conference on Biodiversity 2015 (ICB 2015) on 16-17 November 2015 at Universiti Tun Hussein Onn Malaysia.*

ii. **Ismail, N.** & Maryati, M. (2016). Conserving butterflies (the pollinator) for a sustainable future in *Joint Seminar on Biodiversity & Conservation 2016 on 8 April 2016 at Universitas Gadjah Mada, Yogjakarta.*

Module

i. Maryati, M. & **Ismail, N.** (2017). *Exploring Entomotourism: Butterflies.* Universiti Tun Hussein Onn Malaysia: Module. **(Unpublished).**

CHAPTER 1

INTRODUCTION

1.1 Introduction

This thesis is about distribution of butterflies (Lepidoptera: Rhopalocera) in two forests of Johor: Taman Negara Johor Endau Rompin (TNJER) and Taman Negara Johor Gunung Ledang (TNJGL). TNJER represents a lowland forest dominated by dipterocarps, and TNJGL is a highland forest with highland vegetation at the higher elevation, while dipterocarp still dominates the lower elevation. Spatially some differences were noted between the two forest types.

Distribution was also related to time of collection. As Malaysia has a wet and dry seasons, some variation in the pattern of distribution has been noted. Differences in distribution patterns would implicate the influence of climatic seasonality on the diversity of butterfly. The dynamic pattern of butterfly distribution at different collection time would indicate butterfly as good indicator for climatic variation as well as seasonal changes, thus give benefit in formulating conservation and park management plans.

1.2 Background of the study

1.2.1 Biodiversity in Malaysia

As part of Sundaland biodiversity hot spot, Malaysia is well established as one of the 12 mega-diverse countries in the world (MONRE, 2014). It is characterised by old tropical rainforests which support huge diversity of flora and fauna. There are about

15,000 species of flowering plants, 200 species of palms and 2,500 species of orchids, 286 mammals, 736 birds, 268 reptiles, 158 amphibians and 150,000 invertebrates (MONRE, 2014). However, widespread deforestation and degradation of habitats are causing the decreasing size of tropical rainforest contributing to the loss of flora and fauna species (Sodhi *et al*., 2010).

1.2.2 The two national parks: TNJER and TNJGL

Protected areas in Johor include Endau Rompin and Gunung Ledang National Parks. They are the most prominent and pristine tropical rainforests in the southernmost part of Peninsular Malaysia. Currently, both national parks were fully governed by Johor National Park Corporation (JNPC). These two forest sites harbor rich diversity and high endemicity of flora and fauna especially butterfly (Davison, 1987; Mohamed & Zakaria-Ismail, 2005; Musthapa, Rosely & Othman, 2014; Bakar *et al.*, 2017).

Endau Rompin National Park is situated in two states, Johor and Pahang, with 38,780 ha in Pahang (Kiew, Davison & Kiew, 1987) and 48,905 ha in Johor (Chew, 2007). In Johor, Endau Rompin can be accessed from Selai (Segamat) and Peta (Kahang). During the period of 1976 to 1977, the area in Pahang was heavily logged and eventually ended in August 1978. Meanwhile, in Johor, the logging activity was apparent at the end of 1980s and early 1990s (Aiken, 1984; DWNP, 1996). Later, Endau Rompin was officially gazetted as national park on 2nd September 1993 (DWNP, 1996). This park is one of the remaining lowland forests in the southern part of Peninsular Malaysia and home to great diversity of flora and fauna. It has been known to exist for more than 70 million years and considered as old tropical rainforest, of which, the oldest rock dated in TNJER at least 248 million years old and oldest plant fossil reported at least 160 million years old (Idris, Azman & Rosedean, 1987). Yet, the treasures of TNJER were only recently discovered by several general collections, research projects as well as scientific expeditions conducted by researchers since 1985. It records 62 species of mammals (Davison & Kiew, 1987), 253 birds (BirdLife International, 2016), 47 herpetofauna including amphibian and reptiles (Shahriza *et al*., 2012), 453 taxa of higher plants from 237 genera and 74 families (Chung *et al*., 2005), 104 odonates (Wilson & Gilbert, 2006) and 274 butterflies (Maryati, Ismail & Munjayen, 2013). To date, the documentations

of all plants and animal species are still ongoing and hence, new species of flora and fauna for TNJER might be discovered from time to time.

On the other hand, TNJGL had been gazetted as Johor National Park on 3rd October 2005, covers an area of approximately 8,611 ha, with the highest peak at 1,276 m above sea level (a.s.l.) (JNPC, 2014**)**. This park is one of prominent tourist hotspots in Malaysia due to the popularity of hiking activity and legendary stories of Puteri Gunung Ledang (Fang, 2013). It is also known as the highest highland in the Southern Peninsular Malaysia, which is home to diverse flora and fauna. Moreover, previous reports have recorded 19 species of small mammals (Razak & Yusof, 2014), 67 birds (Azman *et al*., 2014), 10 bats (Shafie *et al*., 2014), 38 herpetofauna (Quah *et al*., 2014), 88 orchids (Zainuddin *et al*., 2014), 143 tree genera (Suratman *et al*., 2015), 14 insects order (Siti-Khairiyah *et al*., 2013) and 31 species of cicadas (Mohd-Tahir & Sulaiman, 2015). So far, preliminary data on butterfly diversity in TNJGL recorded 43 butterfly species (Maryati *et al*., 2014; Siddiki, 2015).

1.2.3 Butterfly and environment

Insect is the most diverse taxon on earth with approximately over 1 million species described (Gullan & Cranston, 2010). Insect has higher diversity in tropical rainforest compared to the other forests as they play significant roles in maintaining the diverse tropical forest ecosystem. Butterflies are frequent diurnal visitors to flowers. Apart from other insects such as beetles, flies, wasps, bees, ants and moths, they also play important role as pollinator to regenerate forest systems and crop production (Kevan & Baker, 1983; Andersson *et al*., 2002).

Ecologically, butterflies are known as good indicators in assessing the quality of the forest and environment (Gullan & Cranston, 2010). They respond rapidly to any habitat (i.e. forest fragmentation, forest disturbance and vegetation different) and environmental changes (i.e. climatic change, temperature, humidity and light intensity) (Brown & Freitas, 2000; Hamer *et al*., 2005; Hazebroek, Adlin & Sinun, 2012). Rapid environmental changes and habitat fragmentation could threaten the richness, abundance and distribution of butterfly communities especially threatened butterfly species which has poor dispersal ability and habitat specialization (Mattila *et al*., 2011). Indeed, most of butterfly species are affected by the changes in

environmental parameters such as different elevation and physiography (Levanoni *et al.*, 2011). The distributions of butterfly species are often restricted to certain altitudes and plant association. In Peninsular Malaysia, about half of butterfly species were recorded below 762 m a.s.l. whereas only 14% (148 species) of the total butterfly fauna (approximately 148 species) could be found above 762 m a.s.l. The rest could occur at both elevations range (Corbet & Pendlebury, 1992).

1.2.4 Malaysia's climate

Malaysia lies in the equatorial zone and the climate is hot with relatively high humidity all year round. The range of daily temperature varies between 21^{o}C to 32^{o}C and the mean monthly rainfall is between 1500 mm to 5000 mm (MetMalaysia, 2017). The maximum rainfall occurs two times which are in October to November and April to May. Meanwhile, the minimum rainfall occur in June to July and February (Wong *et al.*, 2016; MetMalaysia, 2017). The El Nino cycle occurs every two to seven years with each cycle lasting until six to 18 months (MetMalaysia, 2016). Malaysia had experienced the strong El Nino event in 1997 to 1998, which increased the daily temperature (could reach up to 40.1^{o}C) and reduced rainfall (range between 50 mm to 200 mm), resulting in prolonged droughts across Malaysia (Al-Amin & Alam, 2016).

According to the 2007 United Nations Intergovernmental Panel on Climate Change Synthesis Report (IPCC 2007), the 50-years (1956 – 2005) linear warming trend indicated a 0.10 to 0.16^{o}C increase per decade. The temperature in Peninsular Malaysia showed an increase of approximately 2.7 to 4.0^{o}C over the last century (Fletcher *et.al*, 2012). There are many factors that contribute to climate change such as greenhouse gas effect, open burning, land conversion and deforestation (Laurance *et al.*, 2011). Fletcher *et al.* (2012) reported deforestation could increase the maximum daily temperature by 1^{o}C in Pasoh Reserve Forest due to the loss of high vegetation cover and conversion to bare land. Climate and habitat change will threaten the equilibrium of ecosystem as it could alter the interactions of flora and fauna and affect the distribution and diversity of plants and animals. Some animals are able to migrate and adapt successfully, but some species cannot tolerate the effect

of increasing temperature and will be most likely to experience extinction (Foden *et al.*, 2013).

1.2.5 Butterflies' response to climate variations

Insects tend to show rapid responses to climate change as they have very short life cycles and most diverse populations (Wilson and Maclean, 2010). Lepidoptera specifically butterflies represent an ideal biological indicator of ecological change because they are greatly influenced by changes in climate and ecosystems such as temperature, humidity, light intensity and habitat (Boggs & Murphy, 1997). Adult butterflies and their larvae require a maintained body temperature range of 30 to 35 ^{o}C for optimal growth and development (Shreeve, 1992; Van Swaay *et al.*, 2010). Hence, climate change can directly affect their survival rate. Some species may be able to adapt to high temperature, while some may not survive. For example, the shaded area species have shorter lifespan than open area species when temperature increases (Speight, Hunter & Watt, 2008).

Many studies have reported the impact of climate change on butterflies, mostly from the temperate region (Fox *et al*., 2003; Thomas, Franco & Hill, 2006; Heikkinen *et al*., 2010; Cormont *et al*., 2013). However, the lack of comprehensive studies on the diversity and ecology of tropical butterfly especially in the forest in Peninsular Malaysia compared to temperate species have limited our understanding on the impact of climatic variables toward distribution of butterfly communities. In fact, Forister *et al*. (2010) reported some butterfly species have extended their distribution by moving to higher elevations in response to climate change and habitat disturbance. Similar study found moths in Gunung Kinabalu showed the uphill trends as the temperature increased at 0.7°C after 42 years span (1956-2007) (Chen *et al.*, 2009). Given this scenario, altitudinal gradients could be useful in indicating the impact of climatic variations or global warming. Continuous long-term monitoring of butterfly communities could reveal the actual diversity of butterfly fauna in those forests (TNJER and TNJGL), which is vital for conservation effort.

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